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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON YIELD AND NUTRIENT UPTAKE IN RICE UNDER SYSTEM OF RICE INTENSIFICATION

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ABSTRACT

A Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore, during Rabi season, 2010-11 to evaluate the influence of integrated nutrient management practices on rice under SRI (System of Rice Intensification). The experiment consisted of twelve treatments, viz., T_1 – Absolute control (No manures and fertilizers), T_2 – 100% N through inorganic fertilizers, T_3 – 50% N through farmyard manure (FYM) + 50% N through vermicompost (VC), T_4 – 50% N through FYM + 50% N through well decomposed poultry manure (PM) , T_5 – 50% N through well decomposed PM + 50% N through VC, T_6 – 50% inorganic N + 25% N through FYM + 25% N through VC, T_7 – 50% inorganic N + 25% N through FYM + 25% N through well decomposed PM, T_8 – 50% inorganic N + 25% N through well decomposed PM + 25% N through VC, T_9 – 75% inorganic N + 12.5% N through FYM + 12.5% N through VC, T_{10} – 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed PM, T_{11} – 75% inorganic N + 12.5% N through well decomposed PM + 12.5% N through VC, T_{12} – Application of green leaf manure at 6.25 t ha^{-1} + 100% N. The experiment was laid out in Randomized Complete Block Design with three replications. The results revealed that application of 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed PM produced higher grain yield (5802 kg ha^{-1}) and straw yield (8409 kg ha^{-1}) with higher harvest index (0.41) compared to all other treatments. Higher nutrient uptake was also obtained with the same treatment; however, the values are on par with 100% N through inorganic fertilizers (T_2).

KEYWORDS: Rice, SRI, INM, Grain Yield, Nutrient Uptake, Soil Available Nutrients

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INTRODUCTION

Rice is a staple food of 2.7 billion people, almost half the world's population and is grown by more than a half of the world's farmers. In India, rice is the most important and staple food crop for more than two third of the population. The production of rice at all India level is 89.13 million tonnes, in 41.85 million hectares, with productivity of 2130 kg ha^{-1}. In Tamil Nadu, the area under rice cultivation (2009-10) is 19.35 lakh hectares, producing 60.24 lakh tonnes with productivity of 3113 kg ha^{-1} (Anon., 2010). Eventhough the area under rice cultivation is large; the productivity is low due to various interaction factors. The imbalance usage of fertilizers is one of the main factors responsible for the low productivity and also the continuous use of inorganic fertilizers resulted in declining of soil fertility. To obtain the better yield, farmers have used more and more fertilizers year after year due to decline in soil fertility. Moreover, Swaminathan (2002) opined that the green revolution had gradually turned into a 'greedy revolution' as evident in the indiscriminate use of inorganic inputs to attain higher

productivity. The increasing demand for rice grain production has to be achieved by using limited available resources in a sustainable manner. In India, about 40 per cent of the total plant nutrients are consumed by rice crop alone. Though the use of fertilizers per unit area of rice is higher, the fertilizer use efficiency (FUE) is generally low. Importance of organics is increasingly felt these days in sustainable crop production systems.

To achieve higher and sustainable rice yields, use of organic manures is a must (Gill *et al.,* 2008). It is, however, difficult to meet the crop nutrient requirements with bulky organic manure alone and there is a need for integrated application of different sources of nutrients for sustaining the desired crop productivity. Though there are many findings indicating the importance of INM, comprehensive study of appropriate combination or blending of INM practices are lacking in rice under system of rice intensification.

MATERIALS AND METHODS

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *rabi* (2010-11) season. Soil of the experimental area was sandy clay loam in texture, belongs to *Typic Haplustalf*. The pH of the soil was 8.3, EC was 0.45 dSm^{-1}, organic carbon was 0.68 and available N, P, K were 252.0 kg N ha^{-1}, 21.6 kg P ha^{-1} and 481.5 kg K ha^{-1}, respectively. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiment consisted of twelve treatments *viz*., T_1 – Absolute control (No manures and fertilizers), T_2 – 100% N through inorganic fertilizer, T_3 – 50% N through farmyard manure (FYM) + 50% N through vermicompost (VC), T_4 – 50% N through FYM + 50% N through well decomposed poultry manure (PM) , T_5 – 50% N through well decomposed PM + 50% N through VC, T_6 – 50% inorganic N + 25% N through FYM + 25% N through VC, T_7 – 50% inorganic N + 25% N through FYM + 25% N through well decomposed PM, T_8 – 50% inorganic N + 25% N through well decomposed PM + 25% N through VC, T_9 – 75% inorganic N + 12.5% N through FYM + 12.5% N through VC, T_{10} – 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed PM, T_{11} – 75% inorganic N + 12.5% N through well decomposed PM + 12.5% N through VC, T_{12} – Application of green leaf manure at 6.25 t ha^{-1} + 100% N. Rice variety 'CO (R) 50' was used as test variety. The recommended fertilizers *i.e.,* 150:50:50 NPK kg ha^{-1} were applied as urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively in four equal splits. All other package of practices were carried as per recommendation (CPG, 2005). Total nitrogen, phosphorus and potassium contents in the plant sample were analyzed by Microkjeldahl method (Humphries, 1956), Vanadomolybdate method (Jackson, 1973) and Flame photometer (Jackson, 1973) method, respectively. The data were subjected to statistical analysis as prescribed by Gomez and Gomez, 2010.

RESULTS AND DISCUSSIONS

Plant Height

The plant height (cm) was measured at active tillering (50 DAS), panicle initiation (70 DAS), flowering (100 DAS) and harvest (135 DAS) stages and is given in Table 1. The plant height was found increased with age of the crop and the increment was sharp till flowering and mild thereafter. The integrated nutrient management practices significantly influenced the plant height of rice at all the growth stages. The data revealed that application of 75% N as inorganic + 12.5% N through FYM + 12.5% N through poultry manure (T_{10}) resulted in taller plants at different stages of crop growth *viz*., active tillering, panicle initiation, flowering and harvest (70.7, 82.2, 123.3 and 129.4 cm, respectively) which was comparable with the application of 100% N through inorganic fertilizer (T_2) and application of green leaf manure at 6.25 t ha^{-1} + 100% RDF (T_{12}). Shorter plants were recorded in absolute control (T_1) at all crop growth stages *viz*., active tillering, panicle

initiation, flowering and harvest stages (50.8, 65.6, 105.9 and 108.3 cm, respectively).

Growth characters like plant height, number of tillers, drymatter production are the reflective process of effective utilization of resources in a better crop production environment. The plant height is a direct index to measure the growth and vigour of plants. In general, the plant height gradually increased from active tillering to harvest stages and the number of tillers increased up to flowering stage and then deceased at maturity stage. Application of 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure registered taller plants and higher number of tillers m^{-2} at all growth stages and was comparable with 100% inorganics. Integrated nutrient management practices under system of rice intensification may be ascribed to the better macro and micronutrient availability as well as improvement in the physical condition of the soil and also the strong root system was responsible to supply oxygenated energy for production of tillers and their growth through significant uptake of nutrients resulting into luxurious vegetative growth. Results are in line with the findings of Maiti *et al.* (2006), Setty *et al.* (2007), Mankotia *et al.* (2008), Talathi *et al.* (2009a), and Gogoi *et al.* (2010). Poultry manure supplies ammoniacal N during early stage of crop growth and also its higher and steady nutrient release could have resulted better growth and development of the crop and it is in accordance with Devegowda (1997) and Thavaprakaash *et al.* (2008). The better performance of 100% inorganics might be due to more and prolonged availability of plant nutrients to the crop plants. Similar results were also recorded by Singh and Singh (2008).

Drymatter Production

The data on drymatter production (kg ha^{-1}) at active tillering, panicle initiation, flowering and harvest stages are given in Table 2. The treatment had significant influence on drymatter production at all stages of rice. In all the stages, the application of 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure (T_{10}) was found to be superior by recording higher dry matter production and attained maximum during active tillering stage (3338 kg ha^{-1}) and it was on par with treatment involving 100% N through inorganic fertilizer (T_2). Similar results were noted during panicle initiation and flowering stages also. At harvest stage, 75% inorganic N + 12.5% N through well decomposed poultry manure + 12.5% N through vermicompost (T_{11}) and application of green leaf manure at 6.25 t ha^{-1} + 100% RDF (T_{12}) were also on par with T_{10} and T_2. The drymatter production was inferior in absolute control (T_1) at all stages of crop growth, attaining maximum at harvest stage (10864 kg ha^{-1}).

Drymatter accumulation is considered to be the reliable index of crop growth and was significantly influenced by the INM practices. The present study reveals that conjunctive use of organic manure with inorganic fertilizer enhanced drymatter accumulation in rice attaining maximum at maturity stage and is comparable with application of 100 per cent inorganic N. On an average, INM practices increased drymatter accumulation to the tune of 25.4 per cent compared to the control. The increase in drymatter production under INM practices may be attributed to uninterrupted supply of available nutrient from inorganic and organic sources through mineralization and decomposition process. It's implying a stimulatory effect of organic manures application in conjunction with chemical fertilizer on drymatter production capacity of rice and conversely absolute control recorded lower drymatter production. Findings are in accordance with reports of Sujathamma and Reddy (2004), Vanathi and Amanullah (2007), Senthivelu *et al.* (2009), and Talathi *et al.* (2009a). The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of N which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Chaturvedi, 2005).

Grain Yield

The grain and straw yield (kg ha^{-1}) of rice was influenced significantly by the nutrient management practices (Table 3). Among all the treatment, the highest grain yield (5802 kg ha^{-1}) was registered due to the application of 75% N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure (T_{10}). The percentage of increased grain yield due to INM practices (75% N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure) over absolute control was 49.6 per cent. About 10.8 per cent increase was noted over recommended dose of fertilizer due to T_{10}.

The lowest grain yield (2882 kg ha^{-1}) was obtained with absolute control (T_1). Higher straw yield (8409 kg ha^{-1}) was obtained with the application of 75% N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure (T_{10}) compared to other treatments, which was on par with 100% N through inorganic fertilizer (T_2). The lowest straw yield (5849 kg ha^{-1}) was recorded in absolute control (T_1). The highest harvest index (0.41) was registered under application of 75% N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure (T_{10}) and it was comparable with T_{11}, T_{12}, T_9, T_8 and T_7. Harvest index was found inferior (0.33) with absolute control T_1.

The application of organic sources and fertility levels significantly affected the grain and straw yields of rice due to their positive influence on growth and yield attributes. Pandey *et al.* (2001) observed an increased efficiency of inorganic N fertilizer, when it was applied along with organic manures and brought a beneficial effect on rice grain yield. Though FYM, VC and PM are applied on equivalent nitrogen basis, the organic matter content in FYM is higher than the rest. Higher organic matter content would have favourably influenced the grain and straw yield of rice. Harvest index was recorded higher under conjunctive use of FYM and poultry manure along with chemical fertilizer than in sole application of inorganic fertilizer. The increase in grain yield under combined application of FYM and poultry manure along with inorganic fertilizers has led to higher harvest index as documented by Oyekanmi *et al.* (2009).

Nutrient Uptake

Among the treatments, the highest N uptake was recorded under 75% inorganic N + 12.5% N through FYM + 12.5% N through well decomposed poultry manure (T_{10}) at maturity stage and this was on par with 100% N through inorganic fertilizer (T_2) treatment (Table 4). The least N uptake was recorded under absolute control (T_1), which did not receive any organic and inorganic nutrients. Similar trend was followed in P and K uptake at maturity stage. Nutrient uptake is a product of nutrient concentration and drymatter accumulation. The INM promoted nutrient utilization, accounting for better NPK uptake and NPK productivity of rice. Increased uptake might be due to higher availability of nutrients from the soil reservoir and also from the added sources of organic manures (Priyadarsini and Prasad, 2003).

The combined use of organic and inorganic fertilizers was found significantly better than inorganic fertilizers alone for N uptake. Integrated use of organic manures and inorganic fertilizers is helpful in maintaining higher concentration of soil NH_4^+ N for a longer period and restore humus status of the soil ecosystem to holds its fertility and productivity, thus realizing higher N uptake of rice. Kabat *et al.* (2006) also expressed similar views.

Enhanced P uptake with judicious application of organic manures and inorganic fertilizers might be due to a combination of factors that enhance P availability in soils. These include production of organic acids through decomposition of organic matter and subsequent releases of phosphate ions, formation of phospho-humic complexes and isomorphic replacement of phosphate ions by humate ions and also by synergistic effect existing between N and P due to application of organic manures. Such effects on soil P and plant uptake were also reported by Satheesh and

Balasubramanian (2003).

Higher uptake of K might be due to the priming effect of organic manure on decomposition related release of organic acids that solubilise native K. In addition, higher magnitude of increases in K uptake by conjunctive use of organic manures and inorganic fertilizers showed that organic manures presumably play key role in enhancing the use efficiency of applied fertilizer as well as inherent nutrient availability in the soil. This was also documented earlier by Singh *et al.* (2001).

CONCLUSIONS

From the experimental results, it could be enlightened that application of 75% inorganic N + 12.5% N through FYM along with 12.5% N through well decomposed poultry manure could be considered as a better option for achieving higher productivity and nutrient uptake for rice under system of rice intensification. Integrated nutrient management was found to reduce the requirement of inorganic fertilizers without curtailing the yield of rice in addition to increase in the sustainability of the production capacity of the soil. Thus, integrated nutrient management can be more profitable and successful, for system of rice intensification.

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APPENDIX

Table 1: Effect of Integrated Nutrient Management Practices on Plant Height (cm) at Various Growth Stages of Rice

Treatment	Active Tillering (50 DAS)	Pani Cleinitiation (70 DAS)	Flowering (100 DAS)	Maturity (135 DAS)
Absolute control	50.8	65.6	105.9	108.3
100% N INOF	70.2	81.6	118.3	128.4
50% N FYM + 50% N VC	53.3	68.8	106.3	111.9
50% N FYM + 50% N PM	61.7	75.5	107.8	114.7
50% N PM + 50% N VC	60.5	73.2	110.6	113.2
50% N INOF + 25% N FYM + 25% N VC	59.1	73.4	108.0	117.4
50% N INOF + 25% N FYM + 25% N PM	63.4	76.9	115.2	119.7
50% N INOF + 25% N PM + 25% N VC	63.5	77.0	110.4	121.6
75% N INOF + 12.5% N FYM + 12.5% N VC	63.6	77.0	116.3	122.7
75% N INOF + 12.5% N FYM + 12.5% N PM	70.7	82.2	123.3	129.4
75% N INOF + 12.5% N PM + 12.5% N VC	63.7	77.0	116.4	122.8
GLM 6.25 t ha^{-1} + 100% RDF	66.7	80.1	118.0	127.8
SEd ±	2.6	1.9	2.5	3.1
CD (P=0.05)	5.4	4.0	5.1	6.4

Table 2: Effect of Integrated Nutrient Management Practices on Drymatter Production (Kg Ha^{-1}) At Various Growth Stages of Rice

Treatment	Active Tillering (50 DAS)	Panicle Initiation (70 DAS)	Flowering (100 DAS)	Maturity (135 DAS)
Absolute control	1476	3542	7629	10864
100% N INOF	3093	5675	10448	13607
50% N FYM + 50% N VC	2382	4547	8987	12211
50% N FYM + 50% N PM	2589	4716	9127	12253
50% N PM + 50% N VC	2260	4583	9137	12283
50% N INOF + 25% N FYM + 25% N VC	2273	4640	9252	12488
50% N INOF + 25% N FYM + 25% N PM	2129	4686	9298	12788
50% N INOF + 25% N PM + 25% N VC	2117	4509	9192	12826
75% N INOF + 12.5% N FYM + 12.5% N VC	2511	4949	9668	13261
75% N INOF + 12.5% N FYM + 12.5% N PM	3338	5933	10729	14454
75% N INOF + 12.5% N PM + 12.5% N VC	2665	5116	9735	14138
GLM 6.25 t ha^{-1} + 100% RDF	2594	5155	9892	13567
SEd ±	176	198	310	430
CD (P=0.05)	366	412	644	892

Table 3: Effect of Integrated Nutrient Management Practices on Grain and Straw Yield of Rice

	Treatment	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index
T_1	Absolute control	2882	5849	0.33
T_2	100% N INOF	5171	8210	0.39
T_3	50% N FYM + 50% N VC	4476	7204	0.38
T_4	50% N FYM + 50% N PM	4425	7226	0.38
T_5	50% N PM + 50% N VC	4419	7116	0.38

Table 3: Contd.,				
T_6	50% N INOF + 25% N FYM + 25% N VC	4621	7748	0.37
T_7	50% N INOF + 25% N FYM + 25% N PM	4896	7413	0.40
T_8	50% N INOF + 25% N PM + 25% N VC	5097	7719	0.40
T_9	75% N INOF + 12.5% N FYM + 12.5% N VC	5063	7693	0.40
T_{10}	75% N INOF + 12.5% N FYM + 12.5% N PM	5802	8409	0.41
T_{11}	75% N INOF + 12.5% N PM + 12.5% N VC	5206	7633	0.41
T_{12}	GLM 6.25 t ha^{-1} + 100% RDF	5134	7609	0.40
	SEd ±	188	239	0.01
	CD (P=0.05)	390	495	0.02

INOF – Inorganic fertilizer, FYM – Farmyard manure, VC – Vermicompost, PM – Poultry manure, N - Nitrogen

Table 4: Effect of Integrated Nutrient Management Practices on Nitrogen, Phosphorus and Potassium Uptake (Kg Ha^{-1}) of Rice

	Treatment	Nitrogen	Phosphorous	Potassium
T_1	Absolute control	86.91	24.99	43.46
T_2	100% N INOF	113.11	32.68	54.36
T_3	50% N FYM + 50% N VC	97.69	28.09	48.85
T_4	50% N FYM + 50% N PM	98.03	28.18	49.01
T_5	50% N PM + 50% N VC	98.27	28.25	49.13
T_6	50% N INOF + 25% N FYM + 25% N VC	99.90	28.72	49.95
T_7	50% N INOF + 25% N FYM + 25% N PM	102.30	29.41	51.15
T_8	50% N INOF + 25% N PM + 25% N VC	102.61	29.50	51.30
T_9	75% N INOF + 12.5% N FYM + 12.5% N VC	106.09	30.50	53.04
T_{10}	75% N INOF + 12.5% N FYM + 12.5% N PM	115.63	33.24	57.82
T_{11}	75% N INOF + 12.5% N PM + 12.5% N VC	106.73	31.52	53.55
T_{12}	GLM 6.25 t ha^{-1} + 100% RDF	107.54	30.92	53.77
	SEd ±	3.35	0.54	1.67
	CD (P=0.05)	6.95	1.13	3.47